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WHITE OAK IN THE SOUTHERN APPALACHIANS.

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WHITE OAK IN THE SOUTHERN APPALACHIANS.

IMPORTANCE OF WHITE OAK.

White oak is one of the most widely distributed hardwoods in the United States. It is, moreover, the most widely used, and its annual cut of over 2,000,000,000 board feet[a] is more than double that of either red oak or yellow poplar, its nearest competitors. Of the total annual cut of hardwoods in the Southern Appalachian region, excluding Kentucky, white oak forms 49 per cent. No other hardwood is manufactured into as many important commodities.

DISTRIBUTION AND PRESENT STAND.

Although the botanical range of white oak extends as far north as central Ontario and as far south as Tampa Bay in Florida and the Brazos River in Texas, it is most abundant and attains its best development on the western slopes of the Allegheny Mountains and in the central Mississippi and lower Ohio basins.

While logged more or less extensively in all parts of its range for cordwood, cross-ties, and various timber products, the principal bodies of merchantable white oak which have supplied the general lumber trade occupied originally the Ohio basin through western Pennsylvania, Ohio, and Indiana, the central Mississippi Valley as far south as the northern half of Arkansas and central Mississippi, and the long stretch of rolling upland and mountain land extending eastward through Tennessee, Kentucky, and West Virginia to the eastern edge of the Piedmont plateau in Virginia and the Carolinas.

Lumbering in the central hardwood belt began in New York and Pennsylvania, moved westward through the northern Ohio basin, and then south along the Mississippi Valley. Thus the supplies of virgin white oak have largely been exhausted in western Pennsylvania, Ohio, Indiana, southern Illinois, and Missouri. With the central points of the hardwood trade now located at Nashville and Memphis, Tenn., the remaining bodies of white oak timber are found mainly in Arkansas and northern Louisiana, in the southern drainage

[a] Includes cut of chestnut oak and post oak ties.

of the Ohio River, covering Kentucky, West Virginia, and Tennessee, and in the Appalachian Mountains and the western portions of Virginia and the Carolinas. The Southern Appalachian region, as a whole, then, including the Allegheny ranges and the plateaus sloping westward to the Mississippi and Ohio rivers, is now the principal source of supply of white oak and the area of its greatest commercial importance.

The approximate remaining stand of white oak timber in the States comprising the region is given in the following table. These estimates include only timber merchantable for lumber or tight cooperage, and exclude cross-tie material.

TABLE 1.—*Present stand of white oak in the Southern Appalachian region.*

State.	Stand in M feet B. M.
Maryland [a]	130,000
Virginia [a]	1,467,500
West Virginia	4,925,350
Kentucky	2,652,125
Tennessee	2,098,165
North Carolina [a]	1,208,200
South Carolina [a]	93,325
Georgia [a]	387,700
Alabama [a]	140,000
Total	13,102,365

[a] Only the mountainous portions of the State were included to the upper edge of the Piedmont plateau.

The present stand of white oak varies in amount in different parts of the region, and the variations in character and quality are equally marked. In the mountain districts railroad development has been slow, and early logging, confined largely to rafting, took the more marketable poplar and black walnut and left the oak and chestnut in the woods. In the broad belt of rough and inaccessible mountain and plateau land extending through West Virginia and eastern Kentucky there are still large bodies of virgin white oak. The largest and best stands of white oak in the United States are now found in these two States, especially on the mountains of eastern Kentucky. In the higher, more rugged ranges of eastern Tennessee, southwestern Virginia, and the western portion of the Carolinas there are still considerable stands of virgin white oak in the lower, broader mountain coves, though far more scattered and irregular than in Kentucky and West Virginia. East and west of the mountain belt, however, railroad development has been rapid; lumbering has been far more extensive and has been carried on much longer than in the mountains. In the valley districts white oak has been logged more heavily than any other hardwood except walnut and yellow poplar. In many instances accessible timberland has been cut over a second and even a third time for the smaller and rougher trees which were left in the earlier lumbering.

A broad belt through southern Kentucky still contains a fair amount of merchantable white oak, and in the Mississippi district of Tennessee the supply is still abundant. In many other sections, notably the blue-grass regions of Kentucky and Tennessee and the great valley of northwestern Virginia, white oak saw timber is almost exhausted, and the remaining stand is utilized chiefly for cross-ties and similar products. Throughout the plateau districts of Kentucky, Tennessee, and northern Alabama, however, there are still many bodies of virgin white oak varying from a few hundred to several thousand acres in extent.

Two-thirds of the standing white oak of the Southern Appalachian region has been more or less heavily culled. This includes stands from which only the largest and best trees have been taken, as well as areas on which only small, rough timber is left, and extensive stretches of second growth on coaled-over furnace lands along the Tennessee and Cumberland rivers in Tennessee, the New River in Virginia, and portions of the iron district of Alabama. Marked variations in the quality of the white oak timber are seen in different parts of this region. The best occurs in the well-watered valleys of central Kentucky and eastern Tennessee.

THE WOOD AND ITS USES.

The wood of white oak is compact and close-grained, hard, tough, and strong, and heavy. It is durable in contact with the soil, although liable to check in the open air unless carefully seasoned. The average weight of a cubic foot of seasoned wood is 46 pounds.

The three chief uses of the white oak of the Southern Appalachian region are, in order of importance, sawed lumber, railroad cross-ties, and cooperage. Under sawed lumber are included car stock, switch ties, and large timbers for ship and bridge construction.

In the region as a whole, exclusive of Kentucky, about 43 per cent of the annual cut of white oak goes into sawed lumber, about 45 per cent into cross-ties,[a] and about 10 per cent into cooperage stock. About 2 per cent is used for miscellaneous products, such as tool handles, wagon spokes, and furniture and basket veneer.

There is a marked tendency in the region, among the different industries which use white oak timber, to centralize in certain States or sections. Of the total annual production of white oak cross-ties, about 30 per cent is cut in the valleys of the Tennessee and Cumberland rivers in Tennessee and northern Alabama, and form in this section over 90 per cent of the yearly cut of white oak. In Tennessee and northern Alabama as a whole cross-ties form 52 per cent of

[a] This includes also chestnut oak and post oak ties, which are classed with white oak. Chestnut oak and post oak contribute less than 25 per cent of the total.

the annual cut. The cooperage industries are also localized in the valley districts of central and eastern Tennessee and northern Alabama, which produce about 20 per cent of the total annual cut of white oak barrel staves and heading. In the more mountainous region extending through southwestern Virginia, eastern Tennessee, western North and South Carolina, and northern Georgia, tie cutting is largely precluded by the lack of river transportation. The cut of white oak in this section is almost exclusively for sawed lumber.

Sawed lumber now furnishes the chief market for the better grades of white oak timber. Fairly clear, long-bodied white oaks, down to 16 or 18 inches on the stump, are cut for sawlogs. White oak logs are usually sawed into 1 inch, or, when especially good, into 1¼ or 1½ inch boards. Considerable 2 and 3 inch stuff is also cut for use in special industries.

The most important feature of recent years in the manufacture of white oak lumber has been the marked increase in quarter-sawing, a method of milling by which the boards are cut nearly parallel to the pith rays, so that the silver grain is shown. A large proportion of the total cut of white oak lumber is now quartered. Many producers quarter-saw only clear logs 24 or 26 inches and over in diameter at the small end. In this way only the best white oak timber, not more than 15 or 20 per cent of the total amount manufactured, is quarter-sawed, and a high grade of both quartered and plain-sawed stock is thus maintained. Many firms believe that the smaller and rougher logs can not be used as profitably for quartered as for plain-sawed lumber. Other mills quarter everything that is fairly clear, down to 16 or 18 inches at the small end, and claim that the much higher prices for quarter-sawed oak make this method more profitable, despite the waste in manufacture. Under the stimulus of the high prices of 1903 many mills quartered 75 per cent of their total cut of white oak. In Tennessee in that year fully 50 per cent of the output of white oak boards was quartered; the most of the clear logs above 20 inches in diameter at the small end were sawed in this way. As a result of this large output of quarter-sawed lumber from small logs the market was overstocked with narrow, low-grade quartered oak, which caused in part the decline in prices of 1904. In that year the demand for even the best grades of quartered oak fell off sharply, while that for plain-sawed oak remained unchanged. Since 1904 an increasing proportion of white oak has been plain sawed, and many mills now quarter only their best butt cuts. Many of the larger hardwood dealers think that the trend of lumber prices in the last three years indicates the wisdom of restricting the cut of quartered white oak to the better grades of timber.

Quarter-sawed lumber from the Appalachian region is shipped mainly to northern and southeastern furniture and cabinet factories, where much of it is used as a substitute for black walnut, cherry, and mahogany. Some of it is manufactured into panels, ceiling, molding, and other high-grade interior finish. Plain-sawed oak is shipped to planing and finishing mills for manufacture into flooring, ceiling, and other interior woodwork. A great deal is used also in the manufacture of cheaper grades of furniture and for carriages, wagons, farm tools, and agricultural machinery. Considerable white oak lumber of the best grades is used locally in Tennessee for tongues, reaches, bolsters, wheel felloes, and framing. It is the best all-around wood for this purpose, equaling ash, red oak, and chestnut oak in strength and toughness, and excelling them all in durability. The poorer grades of white oak lumber are used locally for flooring and ceiling, or for fencing, storm sheeting, outside finish, and heavy packing cases for pianos and the like.

Large quantities of high-grade white oak dimension stuff and boards, both plain and quarter sawed, are used each year in the manufacture of railroad coaches. There is in addition a special grade known as "car stock," cut from inferior timber and consisting of boards, planking, beams, and dimension stuff of all sizes, which is used extensively in the manufacture of freight and box cars. Car stock is usually cut from small, scrubby timber, or from larger trees which are limby, knotty, or defective from pin worms. Sound knots, stains, "cat faces," and wormholes, all of which lower seriously the grade of ordinary lumber, do not count as defects in car timbers.

Bridge timbers and switch ties are cut from the same kind of material and under the same specifications with regard to defects. Switch ties are 8 inches thick by a 9-inch face, and 9 to 23 feet in length. They are sold in sets of about 50 of varying length. A great deal of white oak was formerly used for trestle piles, but it is now being largely replaced by creosoted longleaf pine.

The logging of white oak cross-ties is confined chiefly to the valleys of the large southern rivers, especially the Tennessee and Cumberland, which furnish cheap transportation to northern railroad centers. White oak, with its great strength, toughness, and durability, is the most valuable tie timber of the South, and to-day furnishes 74 per cent of the total cut of ties in the Tennessee and Cumberland river valleys. Small, rough timber under 16 inches in diameter at the stump is usually taken for this purpose. A few ties are cut from the sapwood of trees felled for sawlogs or stave timber. Sound knots, wormholes, streaks, and small patches of dote do not rank as defects in the ordinary white oak cross-ties.

Tight-barrel staves form the third of the principal uses of white oak timber in the region. The stave industry competes directly with the

lumber trade for the best grades of white oak, taking only clear, straight-grained trees, 18 inches and over in diameter at the stump. With its great strength and close, dense grain, white oak makes the strongest and most valuable staves. It is the only timber generally used for whisky, port, and brandy barrels. White oak staves are used also for kerosene and cotton-seed oil and turpentine cooperage. The common size for whisky-barrel staves is 34 inches long by seven-eighths of an inch thick, with an average width of 4½ inches. A great many white oak liquor staves are still split by hand in the woods and bucked into shape by power. By far the greater number, however, are now sawed by stave mills. In addition to the immense annual cut of staves, about a third as much more white oak is used for heading. It is considered the only wood suited to this purpose, and clear, sound timber of the best grades is required.

Of the secondary uses of white oak, the most important are for veneer, wagon spokes, tool handles, and chair and table stock. For furniture veneer only the best clear white oak is taken, the specifications usually requiring logs 28 inches or over in diameter at the small end. These logs are cut into quartered oak veneer, one-fourth to one-twentieth of an inch thick, for use upon cores of inferior wood. Smaller and rougher white oak timber is used for basket veneer. The strongest and highest priced market and bushel baskets are made entirely of white oak.

Small quantities of very strong, straight-grained white oak are used for wagon spokes and plow handles, and in the manufacture of these short-bodied, open-grown, and second-growth trees are preferred. The material used for chair stock is chiefly small-dimension stuff, an inch or two square. A number of the larger mills have put in special machinery and are now utilizing much of their oak mill cull and waste for this purpose. Larger strips are cut into chair backs, and a few mills are cutting fine quartered-oak table tops in short lengths.

With the diminishing supply of white oak timber, other and cheaper woods have, in many cases, been substituted for it. For wagon stock, tool handles, and farm implements, red oak and chestnut oak are the principal substitutes and are coming into widespread use. Red and black oak and red gum have almost entirely replaced white oak for slack barrel staves, and chestnut oak and red gum are now largely replacing it for oil barrels. For furniture and interior finish chestnut and red oak are in many instances being substituted for white oak.

Probably the most important and extensive substitution, however, has been that of yellow pine in flooring, ceiling, and interior finish, especially in the lower and poorer grades. This substitution is quite common over the entire Appalachian region, as well as in the northern markets, where the southern pines compete with oak for the general

trade. The change is due chiefly to the great difficulty in dressing and filling oak, the increasing scarcity of good timber, and the high market prices of even low grades. In Decatur, Ala., in the summer of 1904 the best grades of plain-sawed white oak flooring and ceiling were quoted at from $48 to $50 per thousand feet, while yellow pine finish of the same grades sold from $16 to $18 a thousand feet. A number of large southern planing mills now manufacture oak finish only on special orders, and many have given it up altogether. Under the exceptionally high prices of 1903 this substitution of yellow pine and other cheaper woods, such as cypress, for white oak finish became more general in northern markets and manufacturing centers than in any previous year. It caused in part the marked depression in the hardwood-lumber market of 1904. The best grades of longleaf pine flooring were quoted on the New York market in June, 1905, at from $21 to $44 per thousand feet, as compared with from $39 to $88 for the corresponding grades of plain and quarter sawed white oak. Thus the increasing tendency is to limit the use of white oak finish to the special or fancy trade and to replace it in the general consumption by red oak, yellow pine, and other cheaper woods.

SILVICAL CHARACTERISTICS.

LOCAL DISTRIBUTION AND OCCURRENCE.

Quality of soil and the amount and uniformity of soil moisture are the chief factors which determine the local distribution of white oak. Though a very widely distributed species, it prefers broad, deep-soiled flats, coves, and gentle lower slopes. While not confined to situations of this character, it is here that white oak is invariably found in greatest abundance, in mixture with chestnut, yellow poplar, red oak, beech, and basswood, and, in the Allegheny ranges, with hemlock and white pine.

ASSOCIATES.

White oak seldom forms a pure forest. On the lower, deeper-soiled situations it occurs in groups, often a half acre or acre in extent. On the poorer slopes and ridges these are less common. In typical mixtures white oak forms more than 10 per cent. A proportion of 10 or 15 per cent of white oak is usually sufficiently high for the forest to be called a "white oak" forest, unless there is a higher proportion of some more valuable species like yellow poplar or white pine.

SOIL AND MOISTURE REQUIREMENTS.

For its best development white oak requires a fresh, porous, loamy, or sandy-loam soil. The finest white oak of the Southern Appalachian region grows in the deep-soiled, broader valleys of West Virginia, Kentucky, and Tennessee. Constant soil moisture, such as

is found in the coves, favors its abundant occurrence and thrifty development, although well-formed trees are often found on comparatively dry soil. Thorough drainage, on the other hand, is essential in all situations.

White oak has a vigorous root system and often establishes itself among the bowlders and broken fragments of very rocky soils if there is but a thin cover of earth and humus to hold moisture and supply the roots with nourishment. On such localities, however, the trees are invariably short-bodied, stunted, and scrubby in form. Sandy soils, on the other hand, are not favorable for white oak. On very sandy areas the trees, if they occur at all, are scattered and of poor development.

FORM.

During the sapling and pole stages white oak on good soils forms a large, thrifty stem, often somewhat curved and with considerable taper. The side branches are very persistent during the early life of the tree, even under a fairly dense forest cover.

On the better cove and valley soils the stems of mature white oaks are fairly straight. Mature stems frequently bear numerous knobs and small irregularities, due to defective pruning, while small sap branches are very common on the trunks of large trees.

The maximum height of white oak on the best valley soils is 150 feet and the diameter 8 feet, with a clear length of 65 or 70 feet. Trees 130 feet in height by 4 feet in diameter are common. The average size of mature trees varies widely on different forest types in the same locality. In Table 2 are given average dimensions of virgin white oaks, 20 inches and over in diameter, breasthigh, on the three main types in the Cumberland Mountains of northeastern Tennessee and in the Tennessee Valley region:

TABLE 2.—*Average size of virgin white oak, according to situation.*

TREES OF CUMBERLAND MOUNTAINS.

Type.	Total height.	Clear length.	Diameter, breast-high.
	Feet.	*Feet.*	*Inches.*
Cove land	95	44	25
Slope land	80	35	24
Ridge land	68	27	21

TREES OF TENNESSEE VALLEY.[a]

Cove land	98	45	28
Slope land	70	30	23
Ridge land	45	18	22

[a] Measurements taken in Perry County, Tenn.

Differences in depth of soil, soil moisture, and amount of exposure, which occur from the coves up to the summits of the ridges, have a marked effect upon the development of white oak, especially upon its total height and clear length, which fall off very rapidly on the poorer sites.

Table 3 shows, for the entire Southern Appalachian region, the relations between the diameter of virgin white oak, breasthigh, and its total height, clear length, and merchantable length:

TABLE 3.—*Relation between diameter, height, clear length, and merchantable length of white oak.*

Diameter breast-high.	Height.	Clear length.	Merchantable length.	Diameter breast-high.	Height.	Clear length.	Merchantable length.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Inches.*	*Feet.*	*Feet.*	*Feet.*
1	11.0	.....	.....	22	89.0	38.0	40.0
2	17.0	.....	.....	23	91.0	39.0	42.0
3	24.0	.....	.....	24	92.0	39.0	43.0
4	30.0	.....	.....	25	94.0	40.0	44.0
5	36.0	.....	.....	26	96.0	40.0	45.0
6	42.0	.....	.....	27	97.0	40.0	46.0
7	47.0	.....	.....	28	99.0	41.0	47.0
8	53.0	.....	.....	29	100.0	41.0	48.0
9	57.0	.....	.....	30	102.0	41.0	49.0
10	61.0	.....	.....	31	103.0	41.0	50.0
11	65.0	.....	.....	32	104.0	42.0	50.0
12	68.0	27.0	17.0	33	105.0	42.0	51.0
13	71.0	28.0	19.0	34	106.0	42.0	52.0
14	73.0	29.0	21.0	35	107.0	43.0	53.0
15	75.0	30.0	23.0	36	108.0	43.0	54.0
16	77.0	32.0	26.0	37	109.0	43.0	54.0
17	80.0	33.0	28.0	38	110.0	43.0	55.0
18	82.0	34.0	31.0	39	111.0	44.0	55.0
19	84.0	35.0	34.0	40	112.0	44.0	56.0
20	85.0	36.0	37.0	41	113.0	44.0	56.0
21	87.0	37.0	39.0	42	114.0	44.0	57.0

The relation between the diameters of second-growth white oak at breastheight and at various stump heights, from 1 to 5 feet, respectively, is given in Table 4, which should prove useful for converting cutting limits, based upon diameter breasthigh, into stump measurements, for the guidance of the logging crews. It will also enable inspectors to check up the work of the choppers, detect any cutting of trees under the specified limit, and enforce contract agreements.

TABLE 4.—*Relation between diameter breasthigh and diameter at different stump heights of white oak.*

Diameter breast-high.	Diameter at various stump heights.					
	At 1 foot.	At 1.5 feet.	At 2 feet.	At 3 feet.	At 4 feet.	At 5 feet.
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
10	13.3	12.3	11.6	10.7	10.2	9.8
11	14.5	13.5	12.7	11.7	11.2	10.8
12	15.7	14.6	13.8	12.8	12.2	11.8
13	16.9	15.8	14.9	13.8	13.2	12.8
14	18.0	16.9	16.0	14.8	14.2	13.8
15	19.1	18.0	17.1	15.9	15.2	14.8
16	20.3	19.1	18.1	16.9	16.3	15.8
17	21.4	20.2	19.2	18.0	17.3	16.8
18	22.5	21.3	20.3	19.0	18.3	17.8
19	23.7	22.4	21.4	20.0	19.3	18.8
20	24.8	23.6	22.5	21.0	20.3	19.8
21	25.9	24.6	23.5	22.1	21.3	20.8
22	26.9	25.7	24.6	23.1	22.3	21.8
23	28.0	26.7	25.6	24.1	23.3	22.8
24	29.1	27.8	26.7	25.1	24.3	23.8
25	30.1	28.8	27.7	26.1	25.3	24.8
26	31.2	29.9	28.7	27.1	26.3	25.8
27	32.2	30.9	29.7	28.1	27.3	26.7
28	33.2	31.9	30.8	29.2	28.3	27.7
29	34.2	32.9	31.8	30.2	29.3	28.7
30	35.1	33.9	32.8	31.2	30.3	29.7
31	36.1	34.8	33.7	32.2	31.3	30.7
32	37.1	35.8	34.7	33.2	32.3	31.7
33	38.0	36.8	35.7	34.2	33.3	32.7
34	39.0	37.8	36.7	35.2	34.3	33.7

The bark of white oak is light, ashy gray in color, and varies greatly in its outer character with the thrift and soundness of the tree. On thrifty trees the bark of the middle and upper stem is formed in long, loose, irregular plates, which make the upper trunk characteristically rough and shaggy like that of shagbark hickory. The bark around the base is hard and firm, and forms an excellent protection against fire.

TOLERANCE.

White oak is comparatively tolerant in early life. Young reproduction will establish itself under a fairly dense overhead canopy if the low undergrowth of saplings and brush is light and broken. While white oak seedlings and sprouts will endure the shade of a high hardwood canopy of considerable density if the ground is clear, they are rarely found under low clumps of saplings, rhododendron, or other shrubby undergrowth. White oak sprouts, nourished by a well-established root system, are somewhat more tolerant than seedlings. This is shown by their ability to thrive under shade, where the growth of seedlings would be slow and stunted.

In the sapling and in the early pole stages, white oak requires at least one-half or two-thirds of the full overhead light for vigorous development. Its growth under adverse conditions, however, while slow, is very persistent, and its power of recovery after the shade is removed is great.

Many white oak trees which have come up under the crowns of old timber and have attained in fifty years a diameter of but 2 inches will, when the mature stand is logged and they receive the light, almost immediately begin to grow rapidly and vigorously.

In the pole stage white oak appears to lose much of its early tolerance. Young trees which have persisted as seedlings and saplings under the shade of an old stand usually succumb to the adverse conditions soon after the pole stage is reached. In middle and late life white oak is distinctly intolerant, enduring but little direct overhead shade. White oak is more tolerant than red and chestnut oak, and, as a rule, outnumbers the two other species in the younger age classes as well as in the mature virgin forest. On the poorer soils of the slopes and ridges, however, and away from the broad central river valleys, where white oak finds its most congenial home, the black oaks tend to replace white oak in both the mature stand and in the young growth coming up beneath it. The great advantage white oak has over the black oak is its marked persistence of growth. This is due partly to its tolerance and ability to recover from suppression when shade is removed, partly to its longevity, and partly to its inherent resistance to decay, insects, and fungus, to which black and red oaks are far more susceptible.

SELF-PRUNING.

White oak is a poor self-pruner. Because of its comparative tolerance in early life, natural pruning is delayed, and occurs mainly in the later pole stage and in middle life. From the sapling period to maturity, even under comparatively dense shade, the bole often bears low, spreading branches, 5 or 6 feet long. The lower limbs of the crowns of white oak poles are very persistent, and when dead often remain on the mature bole as sound, hard stubs, which are shed with difficulty. Except when heavily shaded, white oak, in late life, nearly always forms numerous small sap branches, which, however, do not affect the quality of the timber.

SUSCEPTIBILITY TO INJURY.

In resistance to fire, insect attack, disease, and other injury, white oak is one of the hardiest of Southern Appalachian trees. Its timber runs sounder and freer from damage than that of almost any other important commercial species of the region.

As with all other trees of the Southern Appalachian forests, the greatest source of injury to white oak is found in the frequent, often periodical, fires which are so common in southern woodlands. The effects of these fires upon old white oak timber are seen in stagheadedness, in many scarred and hollowed butts, and the deadening and

removal of the bark and layer after layer of wood. In a few cases this last process is continued until the weakened trees are broken at the butt by the wind, or are twisted off at the root swellings. The actual death of mature white oak from fire, however, is rare. It is killed by spring and summer fires only, or by fires that feed upon the slash left in logging, or upon the trunks and limbs of other more easily killed trees, like chestnut. Far more destructive to mature timber than the actual injury from fire are the attacks of insects and fungi which invariably follow a burn. The weakening of the tree through fire predisposes it to disease and lowers its power of resistance. Certain insects which are destructive to the wood of white oak require some wound or scar through which to gain entrance into the tissues of the tree, while others enter the living bark. (See Yearbook, U. S. Dept. Agric., 1903, pp. 321, 323, and 327.) The opening through which insects enter is, in a vast majority of cases, made by fire. Furthermore, the wounds at the base of the tree readily catch the spores of fungi, and the decay of the exposed wood quickly ensues. White oak is slow to heal over wounds of this character, and even after the scar is closed on the surface the decay goes on within. The result is dote and hollowness, which often extend up the trunk for 10 or 15 feet, or unsound heartwood from red rot, and black, flaky streaks. To all of these injuries, due directly or indirectly to fire, white oak, while often seriously damaged, is more immune than most of the other important Appalachian hardwoods. It is much more resistant than chestnut oak or red oak. While in many badly burned sections a large proportion of the old timber is fire damaged, on the average not more than 10 or 12 per cent of the trees have to be butted in logging on account of dote or hollowness.

A great deal of white oak seed is destroyed every year by light surface fires. In addition, its seedlings and coppice are burned down to the ground and its reproduction confined largely to sprouts from the still living stumps of former growth. On repeatedly burned areas these sprouts become sparse and stunted in development. The burned stumps and roots often become decayed; the fresh crops of coppice are therefore diseased and short lived, and in time the sprouting power of the stumps is exhausted.

The most common and destructive insect which attacks white oak of the region is the oak timber or pin worm, *Eupsalis minuta*, the larva of a small, reddish beetle. According to Hopkins (*ibid.*, p. 323), "the eggs are laid upon the surface or edges of wounds in living trees, and the minute worms, when hatched, burrow directly into the heartwood. The burrows are enlarged and extended in all directions through the trunk. Any wound, such as a dead branch, knot, or slash made with an ax, as well as fire scars, will give the insect entrance into the trunk," but the older trees are always the more

affected. Vigorous, rapidly growing, uninjured trees on good soil suffer much less. As a rule, from 15 to 20 per cent of the white oak in the Southern Appalachians is defective because of this insect, reducing seriously the grade and commercial value of the lumber.

The Columbian timber-beetle, *Corthylus columbianus* Hopk. (*ibid.*, p. 327), known locally as the patch worm, is also common in many parts of the region. It often lowers the grade of white oak lumber and staves by black streaks, "steamboats," or grease spots, formed about the minute holes left in the wood by the insect.

The most serious fungous enemies of white oak are members of the *Polyporus* group, which attack the heartwood of living trees when entrance can be gained through a fire scar or some other fairly deep wound. The dote originating in this way often extends for several feet up the center of the tree, and necessitates heavy culling of the butt log in lumbering. An examination of 1,668 white oak stumps in Greenbrier County, W. Va., shows that trees of any size may become rotten at the butt. Fire is the primary cause of the disease. Dote, however, does not necessarily follow a burn, as shown by the large number of fire-scarred trees which are still sound.

In addition to the fungi which destroy the heartwood, there are numerous species which infest the sapwood of dead, weakened, or badly injured trees. White oak is more resistant to fungous attacks than chestnut, black oak, red oak, and chestnut oak. Decay in its wood progresses slowly, since fungi which enter the tree at the stubs of dead branches usually affect only a small area of heartwood immediately around the point of entrance. The upper parts of the boles are generally sound. Cull on account of unsound, wormy timber is, as a rule, much smaller in white oak than in any of the other oaks.

White oak suffers very little from wind-throw. Almost the only cases of uprooting found are in the coves where the trees, closely sheltered from early life, do not develop their normal wind firmness, and are overthrown by sudden violent gusts which occasionally sweep down the draws or hollows.

Old trees, especially on poor soils and exposed situations, or when weakened by fire, are apt to become wind-shaken at the butt, but white oak is probably the freest of the oaks of the Southern Appalachians from this defect. The proportion of shaky timber in the total annual cut is very small.

REPRODUCTION BY SEED.

The age at which white oak begins to bear seed, the frequency of seed years, and the amount of seed borne in each seed year are all affected by site conditions, especially the amount of light, of soil moisture, and the depth and fertility of the soil. White oak grown in

the open on deep, well-watered soil begins to bear seed when 18 or 20 years old and often bears heavily nearly every year. In open woods seed bearing may begin at 40 years, but under normal forest conditions acorns are not produced, as a rule, before the seventieth or eightieth year.

White oak is comparatively deficient in seed production. Good crops are borne once every four to seven years, and full, heavy crops once every eight to ten years. In dense forest, especially with poor soil and insufficient moisture, seed bearing is less frequent and the crops borne in seed years less abundant. In the intervals between seed years the mast is light or often wholly wanting. Deficiency of seed is often an important factor in limiting the reproduction of white oak. In this respect it is very inferior to yellow poplar, and somewhat inferior to black and red oak and chestnut.

A large proportion of the seed of white oak, moreover, is destroyed by worms, rodents, birds, hogs, and forest fires. Many of the acorns become infested with insects while still on the tree. Often the infested nuts drop prematurely. In other instances, while the germ itself is uninjured, the cotyledons around it are so largely destroyed by the worms that when germination takes place no nutriment is left and the young plant quickly dies. Much seed is destroyed also by drying out on the surface of the ground after falling, and the fall fires either destroy quantities of mast or else remove the leaf litter and expose the seeds to attacks of other enemies. All told, probably not more than 10 or 15 per cent of the total mast produced by white oak escapes destruction from one cause or another.

The seed of white oak begins to ripen and fall by the middle of September, and by middle or late October the entire crop is on the ground. The acorns are disseminated chiefly by gravity and often roll for considerable distances down steep slopes. Squirrels, chipmunks, jays, and crows are also active agents in dissemination. These animals and birds secrete the nuts in the ground; many are subsequently forgotten and thus left in ideal places for germination and thrifty seedling growth.

The percentage of fertility in white oak seed is relatively high, running from 75 to 90 per cent. The acorns germinate in the fall, usually late in October or early in November before the ground is frozen. If the soil and moisture conditions do not at that time favor germination, the seed perishes. It is practically impossible to hold white oak acorns over winter for spring planting.

White oak acorns germinate readily on loose soil if there is a sufficient cover of leaf litter, or if there is shade enough to preclude drying out. Since a certain amount of oxygen is required for germination, it will not take place when the seeds are buried too deep or when the germinating bed is poorly drained.

From a number of causes, therefore, such as scant seed production, destructive enemies, and slow rate of growth, seedling reproduction of white oak is noticeably deficient. In all of these respects black and red oak possess marked advantages over white oak, and tend, as a rule, to crowd it out of the young growth. White oak reproduction of any character is relatively scarce, forming usually less than 15 per cent of the young growth in virgin woods even on lands where this species may form 30 or 40 per cent of the mature stand. In second growth, after lumbering, the scarcity of white oak is still more marked.

There are, of course, numerous local exceptions to this rule. In parts of Greenbrier County, W. Va., the stand of white oak saplings on logged-over coves with deep fertile soil averages 1,475 trees to the acre, or 76 per cent of the second growth. In some of the coves of the Cumberland Mountains recently logged there are upward of 4,000 young white oak seedlings and sprouts to the acre, forming over 80 per cent of all the new growth. White oak invariably holds its own much better in the coves than on the poorer soils of the slopes and ridges. In general, however, it must be classed as a nonaggressive species, deficient in reproduction, and giving way to more hardy and aggressive trees, especially black oak.

SPROUT REPRODUCTION.

White oak sprouts readily from the stumps of seedlings and saplings which have been killed by fire, cropped or trampled by stock, or broken off in lumbering operations. Sprouts of this character, called "seedling sprouts," are especially abundant on lands subject to frequent fires and form, as a rule, 75 per cent of all the white oak reproduction in the region. After logging, white oak sprouts vigorously from the root collars of the smaller stumps, but rarely from the sides or top of the stump.

White oak displays great vigor and persistence in sprouting from the stumps of dead seedlings and saplings. On frequently burned lands six or eight knobs are often found on the end of a single stump, indicating where fresh sprouts have grown out after each successive burn. This power of sprouting afresh after each injury seems to be continued almost indefinitely. On occasional areas, after thirty or forty years of periodical fires, the sprouting power of the stumps is exhausted and no reproduction takes place.

Sprouts from the stumps of felled virgin trees are practically limited to those under 15 inches in diameter. The stumps of old virgin timber almost never sprout. The thriftiest trees, especially those growing in deep, rich soil, sprout most abundantly and retain the power longest. In most localities an age of 120 years marks the limit of vigorous sprouting capacity.

White oak is much less vigorous and persistent in its sprout reproduction than chestnut. This is seen especially in the marked ability of chestnut to sprout from the stump of very large trees and even from the root collars of old trees which have been scorched by fire. Seedling sprouts of chestnut also recover more quickly and sprout more vigorously after a burn than those of white oak. Black oak and red oak are somewhat more likely to sprout than white oak both from the stumps of felled trees and from the stubs of fire-killed seedlings, though less so than chestnut.

GROWTH.

The most important feature of the growth of white oak, as well as the most significant characteristic of the tree, is its inherent persistence. The growth of white oak is comparatively slow. Young trees are often outstripped and suppressed by other species. They will, however, grow slowly but persistently for many years under adverse conditions.

In white oak the duration of vigorous growth is greater than in any of its associates except yellow poplar and possibly chestnut. It retains its vigor and resistant qualities to an advanced age. For these reasons white oak in the long run overcomes and replaces in the mature virgin stands the black and red oaks, which have such a marked advantage over it in early life. As a rule, in virgin woods the proportion of white oak increases steadily in the older age classes. It often forms the bulk of the mature timber in stands where but 10 per cent of the young growth is white oak.

The very slow rate of growth of white oak seedlings under virgin forest, as well as their persistence under adverse conditions, is shown in the last column of Table 5. It is based upon measurements of 77 white oak seedlings in virgin coves in the Holston Mountains of northeastern Tennessee. The forest in this case was exceptionally dense, and the rate of growth is undoubtedly much slower than the average on virgin lands in the region as a whole. The growth of white oak seedlings, however, is slower than that of seedlings of most of the important timber trees associated with it. Under similar site conditions young black and red oak will almost invariably outstrip white oak.

The rate of growth in height of white oak sprouts under virgin woods is given in the three middle columns for the cove and slope types of the Cumberland Mountains and for the cove type of the Holston Mountains.

TABLE 5.—*Height of young white oak at different ages in eastern Tennessee.*

Age.	Cumberland Mountains.		Holston Mountains.	
	Sprout.		Sprout.	Seedlings.
	Cove.	Slope.	Cove.	Cove.
Years.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1	13.0	12.5	10.	4.0
2	40.0	26.0	16.5	5.5
3	57.0	39.5	21.0	6.8
4	70.0	48.2	24.0	8.0
5	82.0	56.0	26.7	9.0
6	.....	.....	29.0	10.0
7	.....	.....	31.0	10.8
8	.....	.....	33.0	11.7
9	.....	.....	35.0	12.4
10	.....	.....	36.6	13.0

The sprouts measured upon the cove lands of the Holston Mountains were growing under an old stand of unusual density, which accounts for their comparatively slow rate of growth. These figures can be compared directly with those for the rate of growth of white oak seedlings, which were obtained from exactly the same coves. By such comparison it is seen that under the same conditions as to soil moisture and light the sprouts of white oak grow about three times as fast during the first ten years as the seedlings.

The rate of growth of young white oak sprouts, while vigorous, is considerably less rapid than that of chestnut and of black oak and red oak. Instances are frequently found in the oak belt of central and western Tennessee and Kentucky where white oak sprouts have been outstripped in growth and badly suppressed by black and red oak sprouts of the same age.

Table 6 shows the growth in diameter of virgin white oak up to 21 inches. It is based on measurements of 509 trees taken in Jackson County, Ky., but represents the average rate of diameter growth of white oak throughout the Southern Appalachian region.

TABLE 6.—*Height and diameter of virgin white oak at different ages.*

Age.	Height.	Diameter breast-high.
Years.	*Feet.*	*Inches.*
20	11	1.1
30	18	2.2
40	25	3.2
50	31	4.2
60	38	5.3
70	44	6.3
80	49	7.4
90	55	8.5
100	60	9.7
110	65	11.0
120	69	12.3
130	72	13.5
140	74	14.7
150	76	15.4
160	79	16.8
170	82	17.8
180	84	18.9
190	85	19.9
200	87	21.0

The development of second-growth white oak after logging, with much better light conditions, is considerably faster than that of virgin timber. Measurements of second-growth white oak were obtained in Decatur County, Tenn., on lands which were cut clean for charcoal from fifty to sixty years ago. The rate of growth of this young timber in height, diameter, and volume is given in Tables 7 and 8.

TABLE 7.—*Relation of height and diameter to age of second-growth white oak in Decatur County, Tenn.*

(Average of all types.)

Age.	Height.	Diameter breast-high.
Years.	*Feet.*	*Inches.*
5	6	0.2
10	12	1.0
15	19	2.0
20	25	3.3
25	31	4.6
30	37	5.9
35	44	7.1
40	50	8.3
45	56	9.4
50	61	10.3
55	66	11.2
60	70	11.7
65	73	12.2
70	74	12.6
75	75	12.9
80	76	13.2
85	77	13.4
90	78	13.6

TABLE 8.—*Volume*[a] *of second-growth white oak of all types, Decatur County, Tenn.*

Diameter breasthigh.	All types.	Diameter breasthigh.	All types.
Inches.	*Board feet.*	*Inches.*	*Board feet.*
10	24	15	106
11	34	16	130
12	47	17	155
13	65	18	180
14	85		

[a] Logs scaled by Doyle's rule.

The better soil and moisture conditions found on the cove and slope lands produce more rapid growth in height and diameter than on the ridges, and much more rapid volume increment.

Table 9 shows the volume of virgin white oak of different breast-high diameters for height classes.

TABLE 9.—*Volume,[a] in board feet, of white oak [in the Southern Appalachian region] for diameters between 14 and 40 inches, arranged in height classes.*

Diameter breast-high.	Volume at various heights.						
	At 60 feet.	At 70 feet.	At 80 feet.	At 90 feet.	At 100 feet.	At 110 feet.	At 120 feet.
Inches.	*Board feet.*	*Board feet.*	*Board feet.*	*Board feet.*	*Board feet.*	*Board feet.*	*Board feet.*
14	55	70	90	115	.....	.....	.....
15	80	95	115	140	.....	.....	.....
16	100	115	140	165	195	.....	.....
17	125	140	165	195	225	.....	.....
18	150	165	190	225	260	.....	.....
19	175	190	220	255	295	.....	.....
20	200	215	250	285	335	400	.....
21	224	245	280	320	375	450	.....
22	250	275	310	355	415	495	.....
23	280	305	340	390	455	545	.....
24	305	335	375	425	500	595	.....
25	335	365	410	465	545	645	.....
26	.....	400	445	505	590	695	865
27	.....	435	480	545	635	750	920
28	.....	470	520	585	685	805	980
29	.....	505	555	630	735	860	1,040
30	.....	535	595	675	785	920	1,100
31	.....	570	630	720	840	985	1,170
32	.....	605	670	765	900	1,060	1,245
33	.....	640	705	815	960	1,140	1,335
34	.....	675	745	865	1,025	1,230	1,445
35	.....	.....	.....	915	1,100	1,330	1,580
36	.....	.....	.....	970	1,175	1,445	1,750
37	.....	.....	.....	1,020	1,270	1,565	1,920
38	.....	.....	.....	.....	1,370	1,690	2,050
39	.....	.....	.....	.....	1,485	1,825	2,170
40	.....	.....	.....	.....	1,625	1,960	2,295

[a] Doyle-Scribner rule.

MANAGEMENT.

OUTLOOK FOR FUTURE SUPPLIES.

Because of its marked deficiency in natural reproduction as compared with other species, the outlook for future supplies of white oak timber under existing conditions is poor. White oak has been more heavily logged than any other of the Appalachian hardwoods except yellow poplar and walnut, and this has further tended to its replacement by the black oaks. The replacement of white oak by black and red oak is common in the second growth of the entire region, and the perpetuation of white oak in commercial quantities will necessitate the adoption of more conservative and far-sighted management of hardwood timberland.

ADVISABILITY OF MANAGEMENT.

With proper management there should be no difficulty in securing either seedling or sprout reproduction of white oak. While the tree is not as prolific a seeder as many of its associates, it reproduces freely, and its moderate tolerance insures greater persistency in the growth of its seedlings and better qualifies them for ultimate survival than those of its less tolerant competitors. Even now there is

a fair representation of young growth from seed in much of the cut-over and second-growth forest; and with protection from fire, the reservation of seed trees, and a reasonable amount of care in logging, an ample reproduction of white oak can be obtained. Sprout reproduction, which is readily secured from trees under 14 inches in diameter, is suitable only for obtaining small timber.

The price of white oak stumpage is high. Low-grade stumpage, or cull and small trees less than 16 inches in diameter breasthigh, sells at from $1 to $2 a thousand feet at an average distance of 5 miles from shipping points; while better grades 20 inches or more in diameter breasthigh, yielding a large proportion of uppers, have, in like situations, a stumpage value of from $10 to $15 a thousand feet board measure.

The growth of large white oak for lumber, however, is profitable only in the best situations, such as coves, lower slopes, and valley lands. On the upper slopes and in other situations unfavorable to the best development of white oak, sprout reproduction, supplemented by light seeding, will yield timber suitable for such products as ties and slack barrel stock.

FIRE PROTECTION.

The first and most essential step in management is protection from fire. This is especially true in the case of young timber and cut-over forests, where the danger from fire is very great. The following protective measures, if carried out, should greatly lessen the fire danger:

1. The construction, wherever possible, of a permanent system of roads. They not only facilitate logging, but also render all portions of a property accessible in case of fire. Roads also serve as initial points in back-firing and will often of themselves check a slow-burning fire.

2. The prohibition or restriction of grazing and swine herding within the forest. In middle Tennessee, and elsewhere where stock has been kept out, there has been a decided decrease in the number of fires.

3. The posting of fire notices, containing the local fire law and offering rewards for evidence leading to the conviction of violators.

4. The cooperation of owners with tenants. Tenants should be made fire wardens, given a nominal and fixed pay with limited pasturage rights for preventing fires, their services being required without additional compensation for fighting fires whenever they occur.

5. The employment of a guard on large tracts, especially while logging is in progress, and for several years afterwards. One man should patrol 15,000 acres.

6. The requirement, when logging is done by contract, that the contractor burn slash when it would become dangerous, organize logging crews into a fire-fighting service which can be used whenever a fire occurs, and, when a railroad is used, maintain a burned strip on both sides of the track.

UNLUMBERED AND LIGHTLY CULLED FOREST.

It is not advisable to cut mature white oak until there is a profitable market for tops and cull trees. From much of the white oak cut for staves and frequently even from that cut for sawlogs, only the choicest lower cuts are taken and the less desirable upper cuts left in the woods. In many cases a profitable sale could have been made of the low-grade timber had the stumpage been held a few years longer. Holding stumpage until the timber can be used with little waste insures the owner a return from the low-grade trees and upper cuts, and at the same time a higher price for the best cuts. It likewise enables the buyer to reduce the cost of logging by the larger stumpage cut. Contracts for the sale of stumpage should require the utilization of all sound timber over 12 inches in diameter in felled trees. The recent rapid advances in the price of car stock, ties, and bridge timber should justify holding white oak stumpage until utilization of such timber is possible. Nor is it advisable to cut white oak when it forms only a small proportion of the mixture unless some of the species of less value with which it is associated—as beech, black oak, maple, and hemlock—can be simultaneously cut.

Because of the relatively small amount of virgin white oak, the use of high-grade timber should be restricted. Frequently very little discretion is displayed in making selection for specific uses, and high-grade logs suitable for plain uppers or quartered stock are converted into bill stock, bridge boards, or even ties or car stock. There is a large amount of low-grade timber and second growth available for these uses, while the amount suitable for high-grade lumber is appreciably lessening each year.

The stumpage value of large trees suitable for high-grade lumber is so much greater than that of small trees that in situations favorable for the best growth of white oak it would be profitable to cut to a high diameter limit—20 or 22 inches breasthigh—and leave the trees below that limit to grow. The rate of growth of the remaining trees should be good and well sustained; old timber should equal or exceed the rate indicated in Table 5, page 21, and second growth should equal or exceed that in Table 6. Under such cutting white oak should be sound and form reasonably long and clean stems. In situations where the large timber is defective and is adapted only to common uses, its

stumpage does not acquire with increased size a sufficiently high value to justify the production of large diameters.

The regions in which the production of large white oak would seem to be most profitable are the coves and valleys of the western slope of the Allegheny Mountains, and the section of Tennessee, Kentucky, and West Virginia adjoining these mountains on the west; the Great Valley, and a small portion of the Piedmont region of northern Virginia. While the conditions are suitable for producing large white oak in many of the coves of the Allegheny ridges and in the Blue Ridge and Smoky mountains, it usually forms only a small proportion of the mixture, frequently as low as 2 or 3 per cent.

In localities where the transportation facilities are poor, where the total stand is not heavy, and lumbering is expensive, the diameter limit might be lowered to 16 or 18 inches.

When beech, sugar maple, red maple, buckeye, hemlock, black oak, hickory, and black gum occur with white oak on the best sites, they should be cut to the smallest possible diameter. Yellow poplar, basswood, ash, chestnut, and walnut, like white oak, should be cut to a high limit, and their young growth should be protected. The fact that white oak often grows naturally in large, pure groups, indicates that, in many situations, its proportion of the mixture could be largely increased. Because of its heavy seed it tends to reproduce in groups and clumps near the seed trees. Two trees to the acre above 14 inches in diameter should always be left for seed trees. Where there is a deficiency in the number of seed trees below the diameter cutting limit, trees should be left above that limit.

The intervals between cuttings should not be less than fifteen years, and preferably should be longer. While cutting at regular intervals is advantageous in keeping the cover somewhat open and stimulating growth, cutting at too close intervals does not give clumps of seedlings sufficient time to become large enough to prevent their being badly broken down in logging. Such clumps should always be protected as far as possible in felling, swamping, and snaking, and neither thrifty young white oak nor young trees of the other desirable species should be used in any of the construction work required in logging when timber of less desirable species is available.

SECOND-GROWTH WHITE OAK.

Second-growth white oak is partly of seedling and partly of sprout origin, but less than 20 per cent of it is seedling growth. In favorable situations seedlings and many of the seedling sprouts are capable of producing large timber, but sprouts in general, especially those from large-sized stumps, will not grow to large sizes. Inferior sprouts can

usually be told by their short stems and extreme taper, and a common characteristic is a swollen butt with a small exposed hollow.

Since second-growth seedling trees are capable of producing large-sized timber the minimum diameter limit for them should be not less than 16 inches, breasthigh for the first cutting, and this should eventually be raised to the limit suggested for virgin growth. Sprout timber may be cut to a diameter of 14 inches breasthigh. After two or three cuttings, sprout growth will be largely eliminated from the forest, and the high diameter limit and heavier cover will eventually prevent much sprout reproduction on these sites. Otherwise, second-growth timber admits of the same management suggested for unlumbered forests.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *May 16, 1907.*

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